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ABSTRACT

This handbook was designed for school-level planners (school site councils, principals, parent groups, and teachers) in developing, assessing, and improving K-12 science education programs. The main body of the handbook (chapter 2) describes the most important components of an effective science education program: (1) school-level plan; (2) classroom implementation; (3) staffing and staff development; and (4) program support. In addition, the elements of exemplary science education programs are described in detail. Assessment questions and examples of activities are also offered. If the school's program lacks many or most of the elements of effective science education described here, it is suggested that improvements will clearly be needed. Chapter 3 reiterates questions from chapter 2 in the form of a convenient checklist designed to be used by school-level planners conducting on-site assessments of school programs. It is assumed that the planners will be visiting science classes, talking with teachers and students, reviewing materials, and comparing what they see with the qualities of an effective program described in the handbook. The checklist serves as a record to later analyze their observations. Various resources are presented in the concluding chapter, such as California State School Resource Centers and a list of state publications. (Author/SK)

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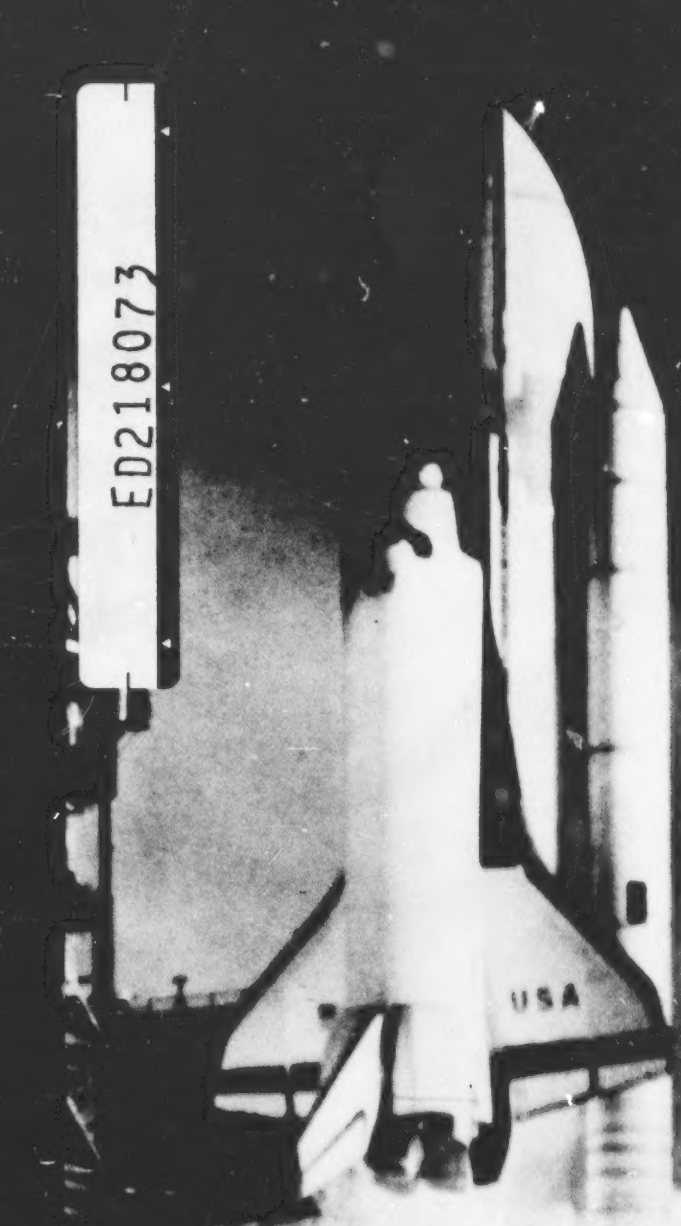
Science Education for the 1980s



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CALIFORNIA STATE DEPARTMENT OF EDUCATION
Wilson Riles, Superintendent of Public Instruction
Sacramento, 1982

Science Education for the 1980s

A Planning and Assessment Handbook for Kindergarten Through Grade Twelve

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A list of other publications available from the Department may be found on page 47 of this handbook.

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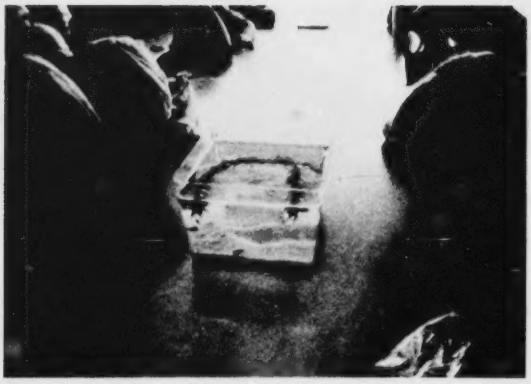


Young people have a natural curiosity about science, and science teachers can play the role of guides on a journey of unfolding discoveries.

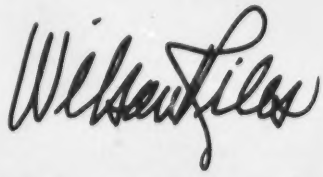
Foreword

One of the most important resources for school improvement is dedicated, imaginative people who have a commitment to quality education—parents, teachers, school administrators, concerned members of the school community, and, of course, the students themselves. This handbook was written for such people. Specifically, it is directed at planners who are concerned with assessing, developing, or improving school-level science education programs.

Assessing science education can be a powerful catalyst for school improvement, because science centers on real things. Science is tangible, exciting, and rewarding. Young people have a natural curiosity about science, and science teachers can play the role of guides on a journey of unfolding discoveries.

Science can link together many other aspects of the curriculum. It can be a focus for writing, reading, art, social studies, environmental education, and multicultural education. Mathematics, of course, is intimately related to many aspects of science.

An improved science education program can open the doors to a wide range of school improvements. Building on the essential elements of young people's natural interests and motivation, science education has nearly unlimited potential for helping our schools meet the challenges of the 1980s. Therefore, I encourage you to use this handbook as you open the doors to school improvement and develop science education programs that will help our young people face the future with the tools they will need to build a better tomorrow.



Superintendent of Public Instruction

Preface

The California State Department of Education has consistently encouraged community and school site planning groups to participate in the school improvement process. Therefore, in keeping with that policy, we have developed *Science Education for the 1980s,* which is one in a series of curriculum documents prepared by the Instructional Services Section of the Department. The handbook is addressed to any individual or group that wishes to review and improve a school science program. However, the document is designed specifically to provide members of the school community, such as parents, teachers, administrators, and subject area specialists, with a standard for assessing and developing science education programs.

This handbook is only one facet of the State Department of Education's overall plan to meet one of its major responsibilities: to provide leadership and assistance to individuals and groups as they work to improve educational opportunities for students. The handbook, which we believe to be unique among assistance documents, is intended to be used in conjunction with other documents, such as the *Science Framework for California Public Schools,* the county superintendents' *Course of Study,* and local planning and curriculum guides.

We sought the assistance and advice of many people who are knowledgeable and experienced in implementing high quality science education programs, and we are very grateful for their valuable contributions and assistance. They are identified in the acknowledgments. Robert Ryan, Science Consultant, California State Department of Education, directed the development of the publication.

The value and success of the handbook will not be confirmed until many of you have had the opportunity to use it. Therefore, as you begin to review your science program, we ask that you take the time to record your experiences, both positive and negative. If you believe we could improve some aspects of the handbook, we genuinely invite your comments. Please direct responses to: California State Department of Education, Instructional Services Section, 721 Capitol Mall, Sacramento, CA 95814.

DAVIS W. CAMPBELL
Deputy Superintendent for Programs

RAMIRO REYES
Associate Superintendent of Public Instruction

JAMES SMITH
Administrator, Instructional Services Section

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This handbook was developed with the assistance of a group of teachers, administrators, science education specialists from higher education, and curriculum developers who met with Department of Education staff over a period of several months. The group, listed below, provided an important link to the latest developments in science education and the needs of schools, teachers, and students:

Jane Bowyer
School of Education
Mills College, Oakland

Gene Deady
School of Education
California State University, Chico

Fred Dobb
State Department of Education

Cliff Fredrickson
San Diego Unified School District

Gerald Garner
Los Angeles Unified School District

Gary Heath
Lawrence Hall of Science
Berkeley

Paul DeHart Hurd
Professor Emeritus
Stanford University

Robert Jones
San Diego Unified School District

Arie Korporaal
Office of the Los Angeles County
Superintendent of Schools

One of the most important resources for school improvement is dedicated, imaginative people who have a commitment to quality education.

Gail Lundholm
School of Education
Mills College, Oakland

Donald Lundstrom
Alameda County Office of Education

George Miller
Department of Chemistry
University of California, Irvine

Rudell O'Neal
Independent Consultant
San Francisco

Karen Reynolds
Oakland Unified School District

William Ritz
School of Natural Sciences
California State University, Long Beach

Mare Taagepera
Department of Chemistry
University of California, Irvine

More than 100 educators and science specialists throughout California reviewed drafts of the handbook, and their contributions to the final draft were significant.

Norma Wilbur
Office of the Los Angeles County Superintendent of Schools

Kay Weil
San Diego Unified School District

Gilbert Yee
Fremont Unified School District

The principal Department of Education staff members involved in the project were James R. Smith, Manager of Instructional Services, and Robert Ryan, Science Education Consultant.

The writers were Henry S. Resnik and Roger Rapaport.

More than 100 educators and science specialists throughout California reviewed drafts of the handbook, and their contributions to the final draft were significant.

Credits for Photographs

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1

Introduction

One measure of the strength of twentieth-century science and technology is the fact that most of their great accomplishments are taken for granted. Penicillin, jet propulsion, rocketry, television, microprocessors, and satellite transmissions are considered a part of everyday life—and keys to a better life—by a generation that assumes science can do almost anything.

It is ironic, then, that support for science education has declined during the last decade. Less than 50 percent of the high school students in the United States take more than one required year of mathematics and one required year of science. Enrollment in upper-level courses like chemistry and physics stands at 16 percent and 9 percent, respectively, of high school students nationwide. Moreover, students in the United States are taking considerably less math and science than students in other countries such as Russia, Japan, and Germany.

New Directions for Science Education

For many years the decline in high quality and well attended science education programs has been a source of concern to educators, policymakers, and leaders of business and industry. That concern has led to a reexamination of the status of science education in the schools and the growing recognition that a knowledge of science is basic to effective citizenship. Fortunately, it comes at a time when student interest in science and related topics is growing.

Where high quality science education programs do exist, they are extremely popular. Magnet schools offering science enrichment programs have long waiting lists. Computer classes attract students for voluntary after-school instruction in programming. Science rooms lure young children off the playground during recess, and participation in science field trips and resident outdoor environmental education programs continue to grow. Young people's enthusiasm for science-oriented museums, fairs, books, periodicals, films, and television shows has never been higher. In addition the demand for new employees in the science, engineering, and computer fields has never been greater than it is today.

Parents and educators are also showing renewed interest in science education, because they are beginning to recognize that science can be an effective and stimulating means of teaching basic skills. Capitalizing on young people's enthusiasm for science projects, teachers can make science a vehicle for instruction in reading, writing, mathematics, and other subjects. Science helps students develop skills in observation, rational inquiry, experimentation, deductive logic, and analytical reasoning. In other words, science helps students learn how to think. An emphasis on sound reasoning and creative thinking is the essence of the best science education programs today.

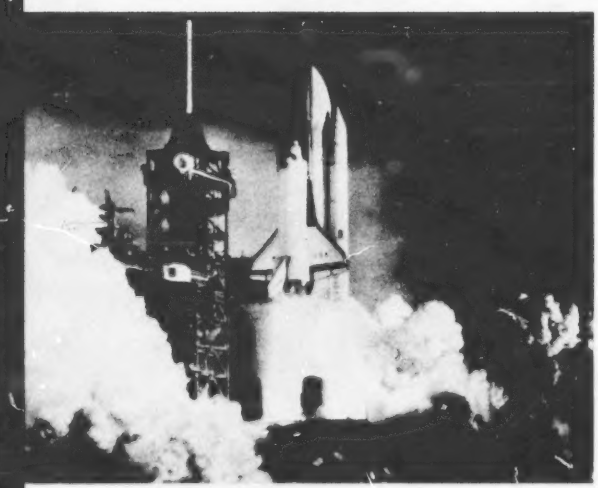
Recognizing the need for stronger science education programs, schools are finding ways to provide funds for science rooms, staff development in science, science kits, and science laboratories inside and outside the classroom. Some schools have developed programs

to assist all teachers in coordinating science with other curriculum areas. Yet, science must compete with many other subjects for declining resources.

Implementing high quality science education requires support from parents willing to inform themselves about the scientific issues of the day. It also requires that public libraries provide a wide range of nontechnical science books; that businesses share their technical expertise and equipment with the schools; that universities assist with staff development; that school site councils provide planning momentum; that parent-teacher organizations help raise funds for such programs; and, of course, that students themselves become involved in science courses.

About This Handbook

This handbook was designed to be a tool for school-level planners—such as school site councils, teachers, and principals—in developing, assessing, and improving science education programs. The writers of the handbook maintain that effective science education is essential to providing students with knowledge and skills that will prepare them for survival in an increasingly complex world.



The main purpose of the handbook is to present a standard for assessing the quality of science education.

The main purpose of the handbook is to present a standard for assessing the quality of science education. For each major component of science education, the handbook offers a narrative description highlighting the key points of that component and a set of questions that will help planners in conducting an assessment of existing programs. In many cases examples of activities are also provided. Together, the narratives, questions, and examples constitute a profile of an exemplary science education program, kindergarten through grade twelve.

Following all the recommendations in this handbook would produce a science education program of the very highest quality. If schools fall short of meeting that standard, the handbook provides criteria for improvement. Yet, it assumes that most schools may need to work gradually toward long-range goals.

The handbook does not provide step-by-step instructions on how to develop or improve science education programs. Nor does it present a rigid prescription. Instead, it offers guidelines and suggestions. Each science education program developed in conjunction with this handbook will be, and should be, unique.

On the other hand, there are a number of ingredients without which science education will fall short of doing an effective job. The handbook defines those essential components.

The focus of the handbook is on school-level programs and activities from kindergarten through the twelfth grade. Although changes in school district policies or state laws could conceivably have an impact on science education at the individual school level, the handbook examines the kinds of program improvements that school-level planners can bring about relatively easily. The underlying assumption is that school improvement can happen without

major changes in state or district policies. It is not necessary to wait for the State Board of Education, the Legislature, or local school district governing boards to require improvements. However, school-level planners can and must work closely with district-level staff in developing and improving programs.

The Audience for the Handbook

The audience for this handbook consists of planners who are in a position to assess and develop school-level science education programs, improve existing programs, and make decisions about science education. An important segment of the audience will be school site planning groups, such as school site councils, that could use the handbook in developing school improvement plans. Groups seeking to implement changes in response to the recommendations of an accreditation team or a program review team are another part of the intended audience.

Although science teachers should be included in such planning groups, the handbook is not intended for science teachers exclusively. This would be a contradiction of one of the handbook's principal goals: to make science education a schoolwide concern, not just the province of those who are most experienced in science teaching. Administrators, teachers from many different disciplines and grade levels, parents, community representatives, and, at the secondary level, students—all might be represented in the planning group.

Given the broadly representative nature of the intended audience, the handbook avoids specialized language and assumptions about advanced knowledge of science on the part of the reader.

Main Parts of the Handbook

The main body of the handbook, Chapter 2, describes the most important components of an effective science education program: the school-level plan; the classroom implementation; staffing and staff development; and program support. In that chapter the elements of exemplary science education programs are described in detail. Assessment questions and examples of activities are also offered. If the school's program lacks many or most of the elements of effective science education described here, improvements will clearly be needed.

Chapter 3 reiterates the questions from the previous chapter in the form of a convenient checklist. This was designed to be used by school-level planners conducting on-site assessments of school programs. Presumably, the planners will visit science classes, talk with teachers and students, review materials, and compare what they see with the qualities of an effective program described in the handbook. The checklist can help them record and analyze their observations.

An important consideration in using the handbook is that its basic purpose is program assessment, not formal teacher evaluation. Visits to classrooms and interviews with teachers are recommended as part of the assessment process. Teacher evaluation,

One of the handbook's principal goals is to make science education a schoolwide concern, not just the province of those who are most experienced in science teaching.

however, is a more formalized process usually conducted by administrators and other supervisory personnel.

Other Resources for School Improvement

Although the handbook does not tell planners precisely how to conduct an assessment or develop a plan for school improvement, it provides a focus for further planning and action. Several other publications from the State Department of Education can be helpful in this process; e.g., the *Elementary Program Review Handbook, Guide for Reviewing School Program Compliance,* and the *Secondary Program Review Handbook.*

School-level planners should also be acquainted with the *Science Framework for California Public Schools,* the *Course of Study—A Program Planning Guide for Grades Kindergarten Through Twelve, 1981—1984,* and the various publications developed to assist schools participating in the School Improvement Program (SIP). Many of these publications may be ordered from the Department of Education's Bureau of Publications (see page 45).

A handbook can only be a guide to school improvement. This handbook and other available resources will not be effective unless they are used by groups of people who are concerned about the quality of education and actively involved in improving it. Improvement of science education must begin with careful, systematic observation of what is happening in a school's science education program—in the classrooms, throughout the school, and in students' involvement with science-related activities both during and after the school day.

This handbook was designed to help school-level planners focus their observations and think creatively about improving science education not just for the present, but for the future. Like science education itself, it can be the beginning of an adventure for all involved.

This handbook was designed to help school-level planners focus their observations and think creatively about improving science education not just for the present, but for the future.

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Science Education Databook. Washington, D.C.: National Science Foundation, 1980.

Science Framework for California Public Schools, Kindergarten and Grades One Through Twelve. Sacramento: California State Department of Education, 1978. (For a list of other Department publications, see page 45.)

What Research Says to the Science Teacher. Washington, D.C.: National Science Teachers Association, 1981.

2

Essential Qualities of an Effective Science Education Program

One of the most significant developments in science today is the level and complexity of scientific knowledge, which has increased so rapidly that no one can grasp it in its entirety. At one time it might have been feasible for schools to try to teach a given body of scientific knowledge on the supposition that it was "complete," but that is no longer possible. Today, education in the processes of science is at least as important as teaching information *about* science, and the entire schoolwide approach to science education is just as important as what is being taught.

Expanding scientific knowledge and new technological developments are changing production and employment patterns and, ultimately, the world economic system. Space and undersea exploration is providing new frontiers in resources and living. The chemical hazards are raising different value-oriented questions. The demise of thousands of species of plants and animals and the diminishing forests and other natural resources give cause for special concern. The energy and water supplies necessary for the future are demanding reconsideration.

Knowledgeable and concerned science leadership and responsible curriculum development are essential parts in creating a preferable future for society. The problems/possibilities for the coming decades should be considerations in planning classroom science activities. Science is no longer an independent discipline; rather, it is interdependent with each of the major areas of curriculum.

Although there is no single "correct" model of a science education program and even high quality programs will vary considerably from one school to another, certain program elements are important enough to be considered essential. This chapter describes four elements that will be found in a high quality program:

- *The school-level plan.* A clear, well designed schoolwide plan is an important building block for effective science education. Without such a plan, science education becomes the province of only those teachers who are most interested in science and, at the secondary level, of those students who are motivated to learn about it. A strong science education program should be based on a commitment to universal standards of scientific literacy that is similar to the commitment to mathematics and language standards that many schools view as their primary goal.
- *Classroom implementation.* No matter what the grade level, several elements of the classroom implementation of science education are critically important. One guiding principle emphasized throughout this handbook is the need for teachers to be aware of and sensitive to students' involvement and interest in what is being taught. Students begin school with enormous natural curiosity about the world around them and how it works; in other words, they have a good deal of self-motivation to learn about science. Too often, however, by the time students get to high school, relatively few of them take science courses. The basic aim of effective classroom implementation must be to sustain the natural curiosity of the

younger child throughout the grades and to shape it into scientific literacy for all students.

- *Staffing and staff development.* A key to the program's success will be staff members who are highly motivated, interested in the subject, and eager to deal with the challenges science presents. Renewal of staff knowledge and skills through carefully planned and continual staff development programs is vitally important.
- *Program support.* Science education programs, particularly at the elementary level, often appear to be constrained by a lack of materials and resources. Although student involvement with interesting materials and hands-on learning experiences is critical, school-level planners can look beyond the conventional sources of materials, such as commercial publishers, and find a wealth of readily available resources.

These, then, are the four basic elements of an effective, high quality program. In the following pages, each element is examined in detail.

A schoolwide commitment to science education reflects the recognition of the entire school community that science is an area of major importance.

The School-Level Plan

Without a clearly defined and broadly supported school-level plan, the science education program's chances of success will be considerably weakened. In the absence of legal mandates of specific time allocations for science and proficiency tests similar to those required for mathematics and language arts, schools must make a deliberate effort to give science education a high priority. Components of an effective school-level plan include:

1. Schoolwide commitment to science education
2. Consistency and articulation throughout the program
3. Clearly specified standards and expectations for homework, grading, classroom behavior, and workmanship
4. Allocation of time for science education
5. Coordination of science with other curriculum areas
6. Provisions for financial support

Schoolwide Commitment to Science Education

An effective science education program cannot be the province of a few teachers working in isolation who happen to be interested or experienced in science. In a strong program a schoolwide commitment to science education reflects the recognition of the entire school community that science is an area of major importance. This means, of course, planning for science education is a part of, not an addition to, any other schoolwide planning effort, such as school improvement and compensatory education.

Such a commitment does not come about spontaneously. It is developed through discussions, analyses of issues, and careful planning of the goals of the entire academic program. It receives clear emphasis in the school's statements about its goals. Science educa-

tion is valued and important for all students, not just for those who are especially gifted or motivated.

When there is a strong schoolwide commitment to science education, parents and other observers visiting the school will be able to see clearly that science has a high priority in the curriculum. There will be displays of science-related projects. Bulletin boards will contain announcements about current events in science. Classrooms will have science corners, shelves of science-related books and magazines, live animals, plants, and other signs of a continuing interest in science on the part of the teachers and students. Furthermore, teachers will set clear standards for learning in science and will require students to acquire basic information essential to understanding modern science and technology.

At the secondary level a wide variety of science courses and mini-courses will be offered to students throughout the school year, and a majority of students will enroll in these courses. Courses will be available not only for the brightest and most able students but also for noncollege-bound students who are interested in learning more about science.

Classrooms will have science corners, shelves of science-related books and magazines, live animals, plants, and other signs of a continuing interest in science on the part of the teachers and students.

Questions for Determining Whether or Not You Are Giving Adequate Attention to School-Level Planning for a High Quality Science Education Program

1. Is a school-level plan for a high quality science education program readily available in written form?
2. Is the plan consistent with local school district policies?
3. Is each teacher in the school aware of his or her role in implementing the plan and able to participate in developing or modifying it if he or she wishes to be involved?
4. Have the planners consulted the *Science Framework for California Public Schools* and the county superintendents' *Course of Study* in designing the plan?
5. Does the plan contain realistic, attainable goals and objectives based on assessed needs?
6. Do the goals and objectives reflect new developments in science and technology with which students will need to be acquainted?
7. Are there regular meetings in which administrators, teachers, parents, students, and others involved in implementing the plan discuss modifications in the plan, ways of implementing it, and ways of evaluating its success?
8. Are science textbooks and related materials available to all students?
9. Are enough textbooks available so that students can take them home?
10. Do the physical setting of the classrooms and the school environment in general support science education? For example, are there displays in classrooms and hallways of science projects and written reports describing science activities? Does the school sponsor an annual science fair?
11. Are all students involved in some aspect of science education?

12. Is science instruction available to students throughout the school year?
13. Do school personnel regularly make information about the science education program available to parents; i.e., through presentations at parent meetings and open houses?
14. Does the plan clearly provide for the allocation of resources (staff, rooms, materials, financial support) for science education?
15. Is at least one person in the school clearly identified as having a leadership role for science education?
16. Is the science education plan an integral part of any other school plan, such as school improvement and compensatory education?

The content of the science program follows a clear, logical, sequential design, and a minimum of overlap exists among classes and grades.

Consistency and Articulation Throughout the Program

An effective science education program is coordinated throughout the school, and the articulation of the science curriculum between grade levels, from kindergarten through twelfth grade, is planned and closely monitored by school staff and others who are responsible for program implementation. Thus, the content of the science program follows a clear, logical, sequential design, and a minimum of overlap exists among classes and grades. This does not preclude repetition of subject matter that may be explored in greater depth at different levels; e.g., in kindergarten a study of light may deal only with shadows; in third or fourth grade, with reflection and refraction; in high school, with wave-length measurement.

The consistency and sequence of the curriculum may be derived from a textbook series; they may also be based on a school- or district-developed curriculum guide that relates several textbooks and related materials to each other. However it is developed, the science curriculum is viewed as a complete entity. It is not a series of separate, individually conceived classroom programs in which each teacher decides what students shall learn.

Wherever possible, the curriculum is consistent with the recommendations of the *Science Framework for California Public Schools,* particularly with regard to content (Goal 4 in the *Framework,* "Scientific Knowledge").

Questions for Determining Whether or Not You Are Giving Adequate Attention to Consistency and Articulation in Your Science Education Program

1. Is the content of the science education program clearly documented in a curriculum guide?
2. Does the program ensure that all students will receive instruction in the basic content areas of science appropriate to their respective grade levels, as described in the *Science Framework for California Public Schools?*
3. Are there procedures that ensure that the curriculum guide is being implemented consistently and uniformly schoolwide;

i.e., are appropriate textbooks and materials being used at the grade levels for which they were designated? Are students regularly assessed to determine if they are acquiring the values, skills, and knowledge specified on the curriculum guide?

4. Do staff members and other school-level planners meet regularly to discuss the consistency and sequence of the curriculum and to make modifications that will continue to support the basic sequential design?
5. Have the school staff and program planners developed methods for maintaining consistency and articulation among science classes?
6. Do students study science in every grade from kindergarten through grade twelve, following the agreed-upon sequential plan?
7. Are all secondary-level students able to enroll in at least one science course each year?
8. Are there provisions for giving remedial work to students who enter the program midyear and who have not covered portions of the curriculum?

Standards and Expectations

One of the most frequently observed characteristics of high quality educational programs is that schoolwide expectations are uniformly high and consistently applied. Students, teachers, and others at the school exhibit positive attitudes toward learning and academic achievement. In fact, learning is seen as the main purpose of the school. Students know what is expected of them in terms of completing homework assignments, getting to class on time, performing academically, behaving in class, and working on projects. For example, in such schools, students who fail to complete homework assignments on time or who come to class late are not allowed to interfere with the learning experiences of others. They know the consequences of not meeting these standards, and they know that the expectations do not vary significantly from teacher to teacher.

Therefore, the school plan should clearly specify the expectations for every student in at least the areas mentioned in the preceding paragraph. The plan should also specify the consequences for not meeting the established standards and the procedures for ensuring a uniform application of the standards.

Students know what is expected of them in terms of completing homework assignments, getting to class on time, performing academically, behaving in class, and working on projects.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Standards and Expectations

1. Have schoolwide standards been adopted for homework, academic performance, classroom behavior, workmanship, and so forth? Are the standards part of the written plan?
2. Are students and parents aware of the adopted standards and the consequences for not meeting them?
3. Are the standards uniformly applied schoolwide?

4. Is academic achievement regarded as a highly positive attribute by teachers, students, and parents?
5. Do students regularly complete homework on time?
6. Are teachers and students on time and prepared to begin work when class begins?
7. Are students and parents aware of the amount and quality of academic work necessary to receive a specified grade?
8. Are students and parents aware of the standards of thoroughness, neatness, care, and precision expected of students in their work?

Allocation of Time for Science Education

In an effective science education program, adequate time is provided for science throughout the school.

One of the weaknesses in many science education programs, particularly at the elementary level, is that relatively little time is devoted to science instruction. In an effective science education program, adequate time is provided for science throughout the school. The amount of time is specified in the plan, and there are procedures to ensure that all students receive science education for the agreed upon time.

It would be naive to think that just allocating a certain number of minutes per day to science guarantees a good program, however. Researchers have distinguished between time devoted to teaching a particular subject and *engaged time,* the time during which students are involved in learning, working on tasks, attending lectures or demonstrations, and participating in discussions.

Program planners should be able to determine that specific and adequate amounts of time are being allocated to the science education program. In addition, they should be able to observe that students are engaged and interested while science instruction is taking place. In some instances this may be difficult to judge from observation. A student may appear to be engrossed in a lecture, but he or she may actually be daydreaming about a totally unrelated subject. Although it will not always be possible to assess actual student engagement in classroom activities, observers should interview students and ask them about their involvement. They should be able to see a variety of different kinds of participation, such as student-led discussions, question-and-answer periods, participation in laboratory activities, reading in the science textbook, and individual and small group work with science materials.[1]

Homework is an effective way to extend the amount of time students spend in learning science education. In both elementary and secondary schools, students should be assigned homework that reviews and reinforces concepts learned in class. High school students should be expected to complete reading assignments before class. In high quality programs, class time is devoted primarily to teacher-student interaction. Rarely is in-class time devoted to students completing a reading assignment.

[1]A more detailed discussion of these issues may be found in *Time to Learn* (a review of the Beginning Teacher Evaluation Study funded by the National Institute of Education). Edited by Carolyn Denham and Ann Lieberman. Washington, D.C.: U.S. Department of Education, 1980.

Questions for Determining Whether or Not You Are Giving Adequate Attention in the School-Level Plan to the Amount and Quality of Time Spent on Science Education

1. Does the school-level plan clearly allocate a specific amount of time for science education for each student during each school week?
2. Can you observe students positively and actively involved in science classes?
3. Are science activities sufficiently varied to allow different kinds of student participation and engagement; e.g., a combination of lectures, laboratory activities, discussions, writing assignments, small group activities, and field studies?
4. Do students complete homework assignments that review and reinforce concepts learned in class?
5. Do high school students complete reading assignments before class time?
6. Are parents contacted when students fail to complete homework assignments on time?
7. Are there well known and uniformly applied consequences for not completing homework assignments on time?
8. Have parents been trained to supervise and assist their children with homework?

When science is coordinated with other disciplines, several learning objectives can be accomplished simultaneously.

Coordination of Science with Other Curricula

As schools today face increasingly diverse demands, time for learning is at a premium. When science is coordinated with other disciplines, however, several learning objectives can be accomplished simultaneously. Science education can play an important role, for example, in helping students improve their skill levels in reading, writing, and computation. Science teachers can help their students meet locally adopted proficiency standards by providing instruction in those basic skills using science content and by providing in-class opportunities which require students to use those skills regularly. Science education can help to develop students' interests, knowledge, and skills in other disciplines in a number of ways:

- *Reading.* Student-initiated reading of science-related books and articles will be an important source of knowledge about science. Science activities can also stimulate reading.
- *Writing.* Even at the primary grade levels, students can begin to write about their observations in science. They can keep science journals; write poems or use other expressive forms stimulated by science activities; write descriptions of experiments, science field trips, or animals in which they are interested; and, of course, prepare lab reports.
- *Oral language.* Teachers can help to develop speaking skills by asking students to give oral reports on science projects or science-related experiences. Oral presentations and discussions can also be an important means of sharpening students' thinking and reasoning skills.

Science education can help to develop students' interests, knowledge, and skills in other disciplines in a number of ways.

- *Mathematics.* To a great extent mathematics is the language of science. Learning mathematics as a part of science can help to make mathematics vivid and meaningful to students.
- *Environmental education.* Many environmental issues in today's world are related to science and technology. These include aspects of soil erosion in relation to development; pollution of air and water; the technology of modern transportation; and conservation of natural resources.
- *Social studies, civics, and history.* The impact of scientific discoveries in this century, beginning with the industrial revolution, is integrally related to the study of history, politics, and government.
- *Health.* As science continues to expand the life expectancy of humans, advances in medicine and personal health are becoming increasingly interconnected.
- *Visual arts.* Documenting and recording science experiments often involve the creation of carefully constructed displays, charts, graphs, diagrams, and drawings.
- *Self-concept.* Science activities provide an excellent vehicle for integrating physically disabled and learning disabled youngsters into the mainstreamed classroom and for developing the self-concept of handicapped students. (For resources see Center for Multisensory Learning, Lawrence Hall of Science, on page 44 of this handbook.)

These are just a few of the ways in which science can be integrated with the rest of the curriculum. At the schoolwide planning level, a commitment must be made to provide for this kind of coordination. Without a schoolwide plan, particularly in secondary schools, the usual isolation of academic disciplines is likely to persist.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Coordinating Science with Other Curricula

1. Do teachers regularly use science content in the teaching of reading, writing, mathematics, social studies, art, and other areas?
2. Are there displays of written essays, reports, poetry, and art projects that incorporate science-related content?
3. Do students keep journals describing what they have learned in science classes or noting the progress of experiments?
4. Do the school staff, parents, and science specialists meet regularly to discuss ways of coordinating science with other areas of the curriculum?
5. At the secondary level have the various departments met to discuss ways of coordinating science education with other disciplines; i.e., using science as a tool for teaching writing or art?
6. Are teachers encouraged and given opportunities to partici-

pate on interdisciplinary teams that allow for a variety of approaches to teaching science and other subjects?

7. Do science teachers make assignments that require students to use their reading and writing skills?
8. Do science teachers help students improve their reading and writing skills when their students are not proficient in those skills?
9. Do science teachers provide opportunities for students to use computation skills in science activities?
10. Do science teachers provide instructional assistance to students whose computational skills in science activities are found to be substandard?
11. Do science teachers appear to be familiar with the locally adopted proficiency standards that their students must meet?

Some Things to Look for

To determine whether or not adequate attention is being given to coordinating science with the rest of the curriculum, one should look for the following:[1]

1. Teachers provide for coordination of curriculum areas by cross-referencing curriculum guides. For example, mathematics guides and science guides are used together in planning lessons in either subject.
2. After observing natural phenomena such as plants, rocks, and weather, students engage in mathematical activities to record what they have observed; e.g., graphing, averaging, predicting, and conducting other statistical procedures.
3. Students keep lists of new vocabulary words they have learned through science projects or science textbooks and magazines. These are reviewed at least once a week. New science words are used to develop crossword puzzles or "hidden word" puzzles.
4. In art classes students develop illustrated books or puppets focusing on science-related subjects; students may also explore symmetry in nature.
5. Students regularly use calculators and computers; courses in computer programming are offered to interested students, and the impact of the computer on the contemporary work force is examined in social studies classes.
6. Students are involved in local ecology activities as field experiences; in school they explore scientific developments related to ecological issues.
7. In history classes students learn about major technological and scientific advances, such as the internal combustion engine, the telephone, modern agricultural techniques, and integrated circuitry; these are related to major historical changes and social problems.

Student-initiated reading of science-related books and articles will be an important source of knowledge about science.

Provisions for Financial Support

Unless the school-level plan includes provisions for financial support of science education, a high quality program will be difficult

[1]Note: The examples here and in the following sections are intended as illustrations only. They are far from being comprehensive.

The proof of the science program will be in its actual classroom implementation.

to attain. Adequate financial support includes:

1. Continuing funding for science education, as opposed to the one-time purchase of science textbooks and materials
2. A balance of expenditures for program components, such as textbooks, laboratory materials, and staff development
3. Provision for release time so that teachers may participate in staff development programs for science education
4. Consideration of science as part of the school's total financial planning, equal in fiscal importance to other high priority areas of the curriculum
5. Provision for discretionary funds for emergency needs and perishable items, such as plants, laboratory animals, and chemicals

Science will be vying with other subjects for its share of the school's financial resources, of course. Many schools are able to draw on a district-supported science materials facility. Others that place a high priority on science incorporate science into various specially funded programs, such as compensatory education and the school improvement program. Moreover, the budget for science education can be amplified by funds for staff development and similar expenditures.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Provisions for Financial Support

1. Has the school administration made a commitment to continuous financial support for science education by providing for it in the school budget?
2. Does the budget provide for a balance of program components, such as materials and staff development?
3. Do teachers have ready access to funds for consumable or perishable materials?
4. Have the staff and program planners investigated a variety of funding sources for science education, including school improvement, compensatory education, and other state and federal programs?

Classroom Implementation

A clearly formulated schoolwide policy for science education provides basic momentum for establishing a quality science program; in some ways it will be the most important ingredient for ensuring the program's success. The proof of the program, however, will be in its actual classroom implementation: in the kind of teaching and learning that takes place, in the ways in which books and other materials are used, in the interaction of the teacher with the students and the students with each other, and in the program's ability to reach beyond the classroom walls to the entire school and the everyday world. This section highlights some of the most

important aspects of the classroom implementation of the science program:

- Course content of the science curriculum
- Teaching methods in science
- A balance of laboratory materials and written materials
- Student learning: involvement, motivation, and special needs
- Careers in science and science-related fields

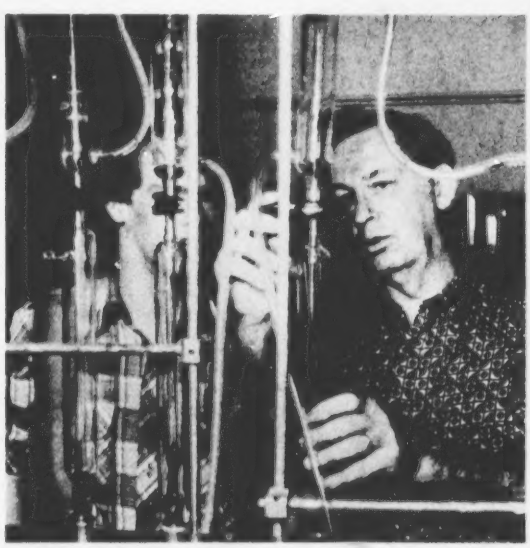
Course Content of the Science Curriculum

The content of the science curriculum cannot possibly encompass all that there is for a person to know and learn in the realm of science and technology. Nevertheless, certain aspects of the science curriculum comprise a core of learning and knowledge upon which science educators widely agree. One basic principle is that a well-planned science curriculum gives adequate attention to the three major fields of science: life science, earth science, and physical science. As outlined in the *Science Framework for California Public Schools,* some important aspects of scientific knowledge, most of which students can begin to learn about in the elementary grades, include, but are not limited to:

- *Astronomy.* Students identify the planets in the solar system, recognize that the motion and path of celestial bodies are predictable, and identify the regular movements of the earth and moon.
- *Biology.* Students identify and describe living things that grow and develop in different environments, recognize that the capture of radiant energy by green plants is basic to the growth and maintenance of living things, and recognize that a living thing is a product of its heredity and environment.
- *Chemistry.* Students recognize that matter exists as solid, liquid, or gas; demonstrate that in chemical or physical changes the total amount of matter remains unchanged; and recognize that in nuclear reactions a loss of matter is a gain in energy and the sum of matter and energy remains constant.
- *Geology.* Students recognize that the earth is constantly changing, that rocks contain one or more kinds of minerals, and that volcanoes change the earth's surface by building mountains.
- *Physics.* Students recognize that energy must be applied to produce an unbalanced force, resulting in motion or change in motion; demonstrate that the amount of energy a machine produces does not exceed the energy consumed; and demonstrate the relationship between magnetism and electricity.

Excellent science education consists of much more than learning facts about science. In a high quality program the purely informational aspects of science education are learned through a strong emphasis on learning science processes. These include:

A well-planned science curriculum gives adequate attention to the three major fields of science: life science, earth science, and physical science.



Excellent science education consists of much more than learning facts about science. In a high quality program, the purely informational aspects of science education are learned through a strong emphasis on learning science processes.

- *Observing.* Using the five senses to find out about objects or events in the environment. Example: Given an apple, the student will be able to describe the apple, using at least three of the five senses (sight: red; touch: smooth; taste: sweet; hearing: crunchy).
- *Classifying.* Grouping objects or events according to their observed characteristics. Example: Given ten pictures of animals, the student will be able to sort the pictures according to whether they are mammals or reptiles.
- *Measuring.* Using standard and nonstandard units and instruments to make quantitative observations. Example: Given a bucket of ice, a glass of water, and thermometers, the student will be able to state the temperature in each container.
- *Collecting and organizing information.* Obtaining information about an object or event and arranging and communicating the information in a meaningful manner. Example: Given a magnet and a variety of objects, the student will find out which items are attracted by the magnet and will record and report the results.
- *Inferring and predicting.* Using previously acquired knowledge to draw a conclusion about an object or event. Example: Based on a study of electricity, when given a battery, two wires, and bulb arranged in a particular configuration, the student will predict whether the bulb will light.
- *Hypothesizing.* Devising a tentative, testable explanation of an event or phenomenon. Example: Given data on plant growth under different environmental conditions, the student will suggest the optimal conditions for plant growth.
- *Identifying and controlling variables.* Limiting the number of changeable factors in an experimental situation in order to obtain valid information to test hypotheses. Example: Given the hypothesis that plants grow better in light, the student will design and carry out an experiment in which the amount of light is varied (and all other conditions are kept constant) in order to test the hypothesis.
- *Process integration.* A synthesis of all the skills described above. Example: Through daily direct observation of the weather using simple instruments, the student will devise an investigation to test a hypothesis about the weather. The student will use measurements and observations, identify the processes of science needed to complete the investigation, and conduct and report in writing the results of the investigation.[1]

The preceding summary of learning processes reflects a progression from relatively simple to relatively complex tasks. This is an important consideration in planning a science curriculum. Chil-

[1]Adapted from the *Irvine Unified School District Elementary Science Curriculum Guide.* Irvine, Calif.: Irvine Unified School District, September, 1980. Used with permission.

dren will not understand information or processes requiring levels of thinking that they have not yet attained. For example, according to recognized experts in child development, it is appropriate to ask children in the second grade to compare and measure objects by identifying one property such as color or shape, but second grade would be too early to introduce scientific experiments dealing with multiple variables. Inferences in scientific experiments would not be appropriate until the middle grades.

Another way of viewing the appropriateness of the curriculum to students' developmental levels is by considering students' general orientation to the world around them. At the elementary level students are most interested in observing and learning about common phenomena in the everyday world—objects and phenomena such as plants, animals, oceans, mountains, stars, and rocks. By the middle and junior high school levels students' interests turn more inward—to themselves and the emotional and physical transitions they are experiencing. At these levels a focus on biology, health, psychology, and human development is more in tune with students' interests and needs. By the time students get to high school, they are ready to become engaged in the various scientific disciplines—biology, chemistry, computer science, and similar fields—as independent modes of study and inquiry. It is also appropriate at this level to emphasize careers, medical science, and the many applications of science and technology in business and industry. In reality, of course, the distinctions are never so clear-cut, because there is great variability in students' development. Even in the elementary grades, some children are able to grasp sophisticated scientific concepts and methods; however, students can learn about science-related careers at all grade levels.

Another way of viewing the appropriateness of the curriculum to students' developmental levels is by considering students' general orientation to the world around them.

A broad view of appropriate content for science education may be found in the *Science Framework for California Public Schools,* and in the county superintendents' *Course of Study,* which categorize science education according to four basic goals. Two of the goals are discussed in the preceding pages: attainment of scientific knowledge—i.e., factual information—and attainment of rational and creative thinking processes. The two other major goals are:

- Attainment of positive attitudes toward science through such experiences as participation in science-related learning and exposure to positive values relating to science
- Attainment of manipulative and communicative skills in science, including the manipulation of materials and equipment; the care and handling of living organisms; and the collection, organization, and communication of scientific information

Questions for Determining Whether or Not You Are Giving Adequate Attention to the Appropriateness of Course Content in the Science Curriculum

1. Have the program planners examined a wide variety of curriculum guides, textbooks, and other materials as part of the process of curriculum planning?

2. Is information in science textbooks and materials valid, accurate, and up-to-date?
3. Is the course content being learned by students consistent with the basic goals of the *Science Framework for California Public Schools:* attainment of positive attitudes toward science; attainment of rational and creative thinking processes; attainment of manipulative and communicative skills in science; and attainment of scientific knowledge?
4. Do teachers stay informed about new materials and significant new developments in science?
5. At the elementary level is there a balance of instruction in life science, earth science, and physical science?
6. At the secondary level is a wide variety of courses offered each year, including advanced courses, general courses, and minicourses in specialized areas of science?
7. Does the sequence of the curriculum reflect students' general orientation to the world around them?

Some Things to Look for

To determine whether or not adequate attention is being given to the appropriateness of the content in the science curriculum, one should look for the following:

1. In every science class clear direction is provided by a text, curriculum guide, or a series of self-instructional science education materials. Students regularly use these materials and are able to identify themes and units that they are studying and have studied in science.
2. Students are able to give examples of various aspects of life science, earth science, and physical science that they have studied in school.
3. Teachers and students introduce new scientific or technological discoveries through regular reports based on reading and television viewing.
4. Teachers promote positive attitudes toward science by encouraging students to recognize the need for energy conservation both at home and in school and to become informed about a variety of science-oriented careers.
5. Teachers promote attainment of rational and creative thinking processes by helping students to observe natural phenomena both in and out of school; to classify, measure, and collect objects; to infer, predict, hypothesize, and identify and control variables through controlled experiments and field study explorations; and to integrate these processes with each other.
6. Teachers promote attainment of manipulative and communicative skills in science by offering students opportunities to measure distances, volumes, and rates through a variety of techniques; to use the International System of Units (SI) metric system; to care for plants and animals; and to gather and record scientific information by listening, reading, researching, graphing, tabulating, developing research papers, and building scientific displays.

One of the major goals in science is the attainment of positive attitudes toward science through such experiences as participation in science-related learning and exposure to positive values relating to science.

Teaching Methods in Science

Successful science teachers use a wide range of instructional methods, which include:

- *Demonstrations.* A skillfully conducted lecture or demonstration can motivate students to learn more on their own.
- *Group experiments.* Students can work together on experiments, and different groups of students can work on different projects at the same time.
- *Modeling.* Since the development of reasoning and inquiry skills should be a basic goal of any science program, the instructor can help students acquire these skills by "thinking out loud" while conducting experiments and demonstrations.
- *Discussion.* Open-ended discussions about science topics can help to stimulate students' reasoning and creative thinking skills. In a well-conducted discussion, the teacher becomes a guide and facilitator; rather than giving students answers, the teacher helps students find answers by themselves.
- *Multimedia instruction.* Where appropriate, the instructor makes use of films, filmstrips, and self-instructional modules that enable students to work independently. Popular television shows and magazines are also introduced as resources for science education.
- *Individual investigation or research.* The instructor encourages students to explore science-related topics and problems on their own and to develop science projects.
- *Student tutoring.* When some students are having problems grasping scientific concepts or techniques, the instructor enlists the help of other students as tutors and teaching assistants.
- *Questioning.* The ability to ask the right kinds of questions to stimulate student learning is critically important to science education, and the effective science teacher asks questions like this unceasingly: "Why did that happen?" "Can you explain how . . . ?" "When I connect this wire with that wire, what do you think will happen?"

Assessing the range of teaching strategies used in science classes will require continued observation over a period of time, because teachers may not vary their teaching strategies noticeably within a particular period or lesson.

Some of the more "traditional" teaching methods are also important to an effective science education program and should not be overlooked. It would be a mistake, for example, if teachers of science become so involved in experiments, projects, and the exciting discovery aspects of science education that they failed to assess student learning through quizzes, tests, term examinations, and carefully supervised student reports. Responsible teachers of science recognize that although science can be inherently motivating for many students, rigorous standards for learning the basics of the science curriculum must be maintained.

Another major goal in science is the attainment of manipulative and communicative skills, including the manipulation of materials and equipment, the care and handling of living organisms, and the collection, organization, and communication of scientific information.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Teaching Methods

1. Do teachers of science use a variety of teaching methods, such as demonstrations, group experiments, modeling, discussion, multimedia instruction, individual investigation or research, student tutoring, and questioning?
2. Do teachers modify teaching methods so that they take into account the needs, strengths, and interests of individual students or groups?
3. At the secondary level are students able to choose among classes and teachers that offer a variety of instructional methods and teaching styles?
4. Do teachers modify strategies on the basis of evaluation data or direct observation that these strategies are not successful?
5. Do teachers of science regularly assess student learning through quizzes, tests, examinations, and reports?
6. Do teachers continually check students to determine whether they are understanding and can give immediate feedback?

A Balance of Laboratory and Written Materials

If it is impossible to determine whether a class is a science class or a class in some other subject, it cannot be a good science class. Materials—and ample opportunities for students to work with and use materials—are an essential aspect of a high quality science education program. Indeed, it is the use of "hands-on" materials and field study that makes science so appealing to many young people who are uninterested in other subjects. In a high quality program, materials of all kinds are readily available.

Successful science teachers use a wide range of instructional methods, which include demonstrations, group experiments, modeling, discussions, multimedia instruction, individual investigation, student tutoring, and questioning.

Students need to learn, however, that there is no clear separation of the hands-on and written aspects of science education—in fact, they are completely interdependent. Especially as students move toward the upper elementary grades, the textbook, the curriculum guide, and the work sheet can become conceptual anchors against the experimentation and free play of ideas derived from laboratory materials and field experiences.

Since materials are expensive and supplies and resources are often scarce, effective science education programs develop ways to ensure that all students will have opportunities to use science materials. These include rotating materials from one classroom or school to another, using low-cost materials commonly available in the home, and designating specific staff members to demonstrate complex experiments that require materials that are expensive or difficult to obtain.

The important point is that the materials become a springboard for other learning, not a temporary source of amusement or curiosity. A terrarium, for example, can provide the basis of numerous lessons about ecology, nutrition, and growth. But unless the teacher uses it as an instructional tool, a terrarium can become just a pretty classroom decoration in which students eventually lose interest.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Creating an Effective Balance Between the Use of Laboratory Materials and Written Materials

1. When laboratory and other hands-on materials are used in science classes, is this done in conjunction with written materials, such as textbooks, activity cards, work sheets, and students' written reports or stories?
2. Are science materials refurbished or replenished on a regular basis?
3. After students have successfully completed laboratory experiments, do teachers encourage them to look for additional insights by referring them to books, periodicals, and other written materials?
4. Are materials for science education readily available to all teachers who want and need them?
5. Are written materials used as both an introduction to laboratory experiments and as follow-up?
6. Do teachers give attention to inventory, ordering, storage, safety, and disposal of materials?

Some Things to Look for

To determine whether or not adequate attention is being given to creating an effective balance between the use of laboratory materials and written materials, one should look for:

1. In elementary classrooms there are science tables, science kits, and science projects. Among many other activities, children are involved in raising and nurturing animals and observing their behavior; then they read about them. Small animals are available to children through a weekend animal lending library, and the children are encouraged to keep a journal describing the animals' behavior and habits. A terrarium is used to illustrate principles of ecological balance, and the teacher relates this to the class' exploration of the ecology of a nearby pond as part of a unit in the science textbook on pond biology. Displays of rocks, shells, leaves, and other objects found in nature are available; in conjunction with these displays, self-instructional work sheets are provided that offer students opportunities to compare, observe, and measure. Balances, rules, thermometers, and other simple measuring instruments are also available.

2. Science classrooms at the high school level contain diverse materials, such as burners, beakers, and test tubes of various sizes; chemicals; microscopes; specimens; and prepared slides. These materials are regularly used to complement lessons in the textbooks on chemistry, biology, and related subjects. On the walls are posters illustrating the table of elements, human anatomy, laboratory safety rules, and recent scientific and technological developments. Bulletin boards are used to report on science-related current events and job opportunities for teenagers. Reports on original experiments developed by participating students are prominently displayed.

It is the use of "hands-on" materials and field study that makes science so appealing to many young people who are uninterested in other subjects.

Student Involvement, Motivation, and Special Needs

One of the most important elements of an effective science program in the elementary grades is sustaining students' sense of discovery and excitement in exploring the world around them. When this internal motivation is supported by active involvement and participation in science activities, students are motivated to grapple with the more difficult and challenging aspects of science that they encounter in the upper grades. Unless their motivation is nurtured and supported, they begin to think of science as a difficult, frustrating subject reserved exclusively for math wizards and budding geniuses.

One of the most important elements of an effective science program in the elementary grades is sustaining students' sense of discovery and excitement in exploring the world around them.

Teachers who wish to sustain student motivation and curiosity lead students in the discovery process and step back from the traditional teacher role of providing answers and correcting mistakes. Successful teachers of science are open to the learning value of "wrong" answers. They are comfortable saying, "I don't know. Let's investigate."

In a high quality science program, teachers are able to modify activities and lesson plans in order to build on current events in science such as science-related news. The teacher is always sensitive to students' involvement, interest, and ability to understand the concepts and processes being taught. The teacher also makes provisions for involving students with special needs. The classroom or science center may contain materials and experiments designed specifically to involve blind children, for example. When necessary, the teacher may assist handicapped students personally or create teams of nonhandicapped students in which the former act as peer teachers.

Similarly, a strong science program makes provisions for students who have limited proficiency in English. The program is designed so that a lack of English language proficiency is not a barrier to mastering science concepts, skills, and facts. If instruction for students with limited proficiency in English is given in the students' primary language, teachers have sufficient materials in the students' primary language and are provided with a glossary of scientific terminology in that language. If instruction is in English, simplified language is used that builds on students' ability to understand, and visual and concrete materials are used extensively as a means of communication. In all cases, however, to the extent possible, the content of the science program for students with special needs is the same as that learned by all other students. Both for students with limited proficiency in English and handicapped students, oral tests, tests in the students' primary language, and other means of assessment are used that help to avoid discriminating against students who are unable to take or understand conventional written tests.

An effective program also provides opportunities for students who are highly motivated in science to learn about and participate in national, state, and local science fairs and competitions.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Sustaining Student Involvement and Motivation

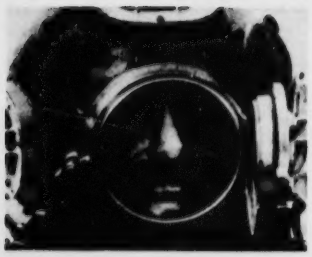
1. Do teachers allow time for open discussion of science and related topics so that students feel free to ask questions?
2. Do teachers modify lessons, when necessary or appropriate, to take students' needs and interests into account?
3. Do students have opportunities to initiate scientific investigations and explorations in areas of special interest?
4. Do teachers translate discussions of current events into interesting science activities?
5. Do teachers encourage students to explore science-related issues and to test hypotheses?
6. Are there sufficient science materials for students who have limited proficiency in English, and are teachers using these materials sensitively and adequately?
7. Are students who have limited proficiency in English as involved in science classes as students who are fluent in English, and are they learning the same concepts as students who are fluent in English?
8. Do handicapped students have adequate opportunities to participate in science classes, and do teachers of science provide handicapped students with adequate opportunities and special learning materials to become actively involved in laboratory activities? Are handicapped students learning the same concepts as nonhandicapped students?
9. Do gifted and talented students have adequate opportunities to pursue science projects and interests in science independently, in groups, and in tutorials with teachers, older students, and volunteers?
10. Does the school provide science-oriented extracurricular activities, and do teachers regularly make students aware of such activities outside school?
11. Has the staff of special programs (e.g., special education teachers, bilingual education teachers) been involved in the planning of the science education program?

Some Things to Look for

To determine whether or not adequate attention is being given to keeping students involved and motivated in science, one should look for the following:

1. Students regularly and frequently share with the rest of the class unusual experiences with pets, geographical phenomena observed during trips or vacations, or aspects of health and medicine about which they may have questions. These are used as starting points for activities and further study.
2. A science question box or board is prominently displayed in the classroom. Periodically, the teacher takes time to read students' questions and discuss them. If no one has an answer, research and experiments are conducted to determine if there are answers.

To the extent possible, the content of the science program for students with special needs is the same as that learned by all other students.



3. Students investigate, through models or textbooks, how familiar things work; e.g., the telephone, television, record players, automobile engines, airplanes.
4. Multisensory instructional materials that give handicapped students access to scientific investigations are available. Classroom materials include visual and tactile aids, lessons on audiocassettes and in braille, and tools and activities appropriate for physically handicapped, learning disabled, and other students with special needs. (For information about the SAVI/SELPH Program and other resources available from the Center for Multisensory Learning, Lawrence Hall of Science, see page 44.)
5. Classroom aides and peer teachers regularly assist students with special needs so that they are continually involved in learning science.
6. Students who are particularly interested in specific scientific topics regularly share information with the class about these topics, bring collections from home to display in the classroom, and lead class discussions.

Careers in Science and Science-Related Fields

A casual glance at the classified section of nearly any newspaper will document the shortage of trained personnel in the computer sciences, engineering, medicine, and the physical and biological sciences. Despite the attractive opportunities that are available, many students need encouragement in exploring science-oriented careers. Equally important, science is relevant to many other careers that would not be categorized as "scientific": law, health, government, psychology, transportation, agriculture, and many other fields.

Career counseling, the active encouragement of parents and teachers, and the involvement of local employers are all necessary to help inform students about science and engineering careers.

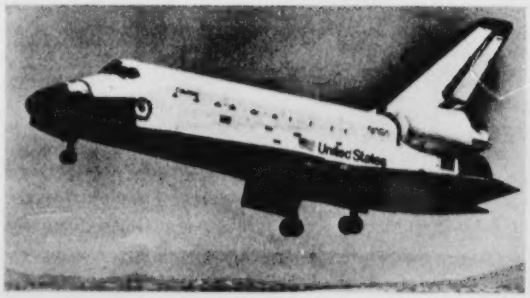
A high quality science program helps to demystify the scientist's role in society. Career counseling, the active encouragement of parents and teachers, and the involvement of local employers are all necessary to help inform students about science and engineering careers. Some schools offer "shadow" programs that allow students to spend a day or so with people in science-related careers to see what their work is like. Particularly accessible to California students are facilities specializing in computer sciences, electronics, engineering, and agriculture.

An important aspect of science-oriented career education is the need to counter familiar stereotypes of the scientist as a sober, white-coated male who never leaves his laboratory. High quality programs expose students to a variety of professionals that include women and members of different age and ethnic groups.

Science-oriented career explorations should not be offered just to students who are taking upper-level science courses. As many students as possible in a high quality program are encouraged to enroll in advanced mathematics, chemistry, and physics courses. Enrolling in these courses is often the first step in pursuing a scientific career. Taking these courses may also be helpful for those entering nonscientific careers. In addition the courses can help prepare students for citizenship in our advanced technological society.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Careers in Science and in Science-Related Fields

1. Do students at all grade levels and ability levels have opportunities to meet and talk with people in science-related fields, both in school and in their job settings, to learn what they do, and to explore long-range career goals?
2. Are students aware of the need to maintain career options by taking as many mathematics and science courses as possible?
3. Are students regularly provided with information about science-oriented job opportunities for teenagers and entry-level positions in science-related occupations that may not require advanced science courses?
4. Do students know the requirements and recommendations for admission to specific college programs involving science?
5. Does the school offer courses and other opportunities for noncollege-bound students to pursue science-related careers, and do students take them?
6. Are school counselors aware of and informed about science-related career options?
7. Do teachers of science make information about science-oriented careers available and offer career counseling to students who request it?
8. Do students know where they can obtain counseling relevant to science-oriented careers?
9. Do graduates of the school visit the school regularly to offer students information and counseling regarding science-oriented careers?
10. Do the school's science teachers assist the guidance department in acquiring and maintaining current and reliable information about science-oriented careers for counselees?



Are students aware of the need to maintain career options by taking as many mathematics and science courses as possible?

Some Things to Look for

In order to determine whether or not adequate attention is being given to careers in science and science-related fields, one should look for the following:

1. Groups of students periodically make field trips to airports, factories, engineering plants, computer firms, chemical plants, and similar job settings to observe science-related occupations first hand.
2. Professionals in a variety of science-related careers, including role models for minorities and females, meet with students at school in a small group or individually to discuss their jobs, answer questions, and suggest qualifications for employment in their fields.
3. Parents involved in science-related careers meet with classes to talk about their work and how their careers evolved.
4. Students read books, write reports, see films, or do role plays describing the lives of famous scientists and inventors.
5. Students research, document, and report about career ladders that are found in science-related professions; e.g., entry-level jobs that can lead to advancement through in-service training and company-sponsored educational opportunities.

Staffing and Staff Development

One of the perennial truths of education is that teachers teach best what they are most familiar with and most skilled at teaching. A school's educational program cannot be better than the skills of its teaching staff. These truisms may apply more to science than to almost any other curriculum area.

Weak science education programs almost invariably involve teachers who are required to teach science, regardless of their interest or background in science education. An effective science education program builds on a foundation of enthusiastic teachers who are highly skilled in science, committed to science education, and eager to teach the subject. At the elementary level this may require teaming and pairing of teachers and rotating of classes in order to make high quality instruction available to all students. At least one able, committed science teacher is essential to a successful program. Poor textbooks, inadequate materials, a lack of space and resources, and many other deficits will be tolerable if the school has such a teacher; but without one, the most luxuriously equipped laboratory or science room will be of little use.

In addition to a core of qualified science teachers, the program can benefit greatly from other forms of supplementary staffing, such as:

1. Resource teachers from special programs or the district office
2. Parent volunteers who have particular skills or experience in science-related subjects or fields
3. Representatives of business, industry, community service organizations, and institutions, such as museums, who are able to visit the school on a regular basis to offer demonstrations, lectures, and other activities
4. Volunteers and interns from nearby college and university science departments—either students or faculty members—who have an interest in science education
5. Secondary school science teachers working with elementary students

A high quality program explores these and many other resources. The heart of the program, however, is day-to-day science education offered by regular members of the school staff.

One of the perennial truths of education is that teachers teach best what they are most familiar with and most skilled at teaching.

Staff Development In Science Education

Skills and knowledge can be developed in the staff just as they can in students; and, just as with students, staff will learn best when good teaching practices are employed in the staff development program. This includes dealing effectively with the staff's motivation to learn new skills and knowledge. The staff is more likely to take an active part in the staff development program when they have participated in identifying training needs and in developing the training design. They are more likely to incorporate the newly learned skills and knowledge in their teaching when the staff development program is well wrought. Such a program includes:

- *Administrative support.* Research has shown that staff development programs are more likely to have a positive impact on schools when the principal participates.[1] Administrative support must be continual and genuine.
- *Specificity.* Effective staff development programs are concrete, and they are designed to develop specific skills—as contrasted with programs that consist solely of presentations, overviews, and generalities.
- *Opportunities for practice.* Effective programs offer participants opportunities to observe new skills being used; to practice using these skills themselves in a nonthreatening, experimental situation; and to experience nonjudgmental critiques of how they use the skills on a continuing basis in and out of the classroom.
- *Individualization.* Effective programs are designed to meet the needs of individual schools and teachers; when necessary, training is modified to accommodate needs that are identified after training has begun.
- *Continuation over time.* Isolated staff development programs are rarely effective in changing teachers' behavior and methods. In order to have a lasting impact, staff development must continue over a period of time, often an entire school year, and provide follow-up and support for the development of new skills and program approaches. In addition, staff development should be a lifetime concern of teachers in order for them to stay informed of new developments in science.
- *Opportunities to observe master teachers or colleagues with special skills.* Role modeling of new skills by master teachers and colleagues can be a major factor in the success of a staff development program. It is often used to initiate training in new skills so that participants can observe the particular skills in use, learn from role models, and then try the skills themselves.
- *Follow-up.* The participants can benefit from regular meetings to discuss problems, successes, frustrations, questions, and achievements associated with the new skills or approaches they have learned. Further training may be required as new needs are identified.
- *Coaching.* In order to assess the effectiveness of the training and the participants' ability to use the skills that have been introduced or refined, the trainer or a supervisor or another colleague will visit the participants' classrooms at a prearranged time to observe how well the staff has incorporated the skills into actual classroom practice. These sessions are intended for feedback rather than formal evaluation, and the observer will use them as an opportunity to improve skill deficits or offer praise for good teaching.

Skills and knowledge can be developed in the staff just as they can in students; and, just as with students, staff will learn best when good teaching practices are employed in the staff development program.

[1] "Synthesis of Research on Staff Development," prepared by the ERIC Clearinghouse on Educational Management. *Educational Leadership*, Vol. 38 (November, 1980), 182—185.

The logistics of the staff development program will be a factor in its success. Some schools are able to deliver high quality staff development on a regular basis by dismissing students early one day every other week or once a month. Schools participating in some state programs, such as school improvement, are eligible to release students for up to eight days and still receive state funding for those eight days. Others use specially designated funds to pay for substitutes, allowing teachers release time to participate in staff development programs.

One of the most successful approaches to staff development, particularly when teachers need the opportunity to try new techniques in the classroom without the fear of failing, is an intensive workshop of a week or several weeks during the summer, held in conjunction with an experimental summer program. This gives teachers an opportunity to try out new techniques and materials in actual classroom situations without the pressure and anxiety of the normal school year.

Conversely, one of the least successful approaches to staff development is the after-school workshop or training session. Even when teachers volunteer to attend such sessions, they are usually tired from their day's work and not inclined to become actively, enthusiastically involved.

Questions for Determining Whether or Not You Are Giving Adequate Attention to Staffing and Staff Development

1. Are the teachers who are most interested and skilled in science responsible for teaching it?
2. Is supplemental staffing available through the use of aides, resource people, specialists, volunteers, interns, and visiting teachers from community agencies, science centers and museums, and colleges and universities?
3. Are parents and others in the community who are knowledgeable or experienced in particular aspects of science involved in planning and implementing the program?
4. Do school staff members assist in designing staff development programs based on clearly identified needs?

Do school staff members assist in designing staff development programs based on clearly identified needs?

5. Is the staff development program consistent with the school's planned program for science education?
6. Do staff development programs continue over an extended period of time, allowing for training, skill development, classroom observation, additional follow-up, and coaching?
7. Do the timing and logistical arrangements of staff development sessions enable teachers to participate with a minimum of fatigue, disrupted schedules, and loss of time in the classroom?
8. Do teachers have opportunities to practice new skills that they are learning or experiment with new materials before trying them out in the classroom?

9. Does the staff development program help teachers gain specific skills and techniques and secure materials that can be immediately useful to them?
10. Does the school have a professional library with current science materials so that teachers are continually able to come in contact with new ideas and developments in the field, and do teachers use this library regularly?
11. Does the staff development program provide for such important aspects of a high quality science program as the renewal and updating of information about scientific developments; research relevant to science education; and ways of coordinating science education with instruction in other disciplines?
12. Do teachers participate in professional organizations, meetings, and conferences in order to upgrade their skills in science education, and are they encouraged to do so by the school administration?
13. Is there support at the district level for teacher in-service training programs?

Support for the Science Program

Because science and technology have become such dominant forces in modern life, countless opportunities are available for the school's science education program to interact with and draw upon resources throughout the school community. An effective program uses these opportunities as much as possible. This connection of science education with the real world makes it rich and meaningful in a way that classroom instruction alone cannot.

Selection of a Basic Science Textbook

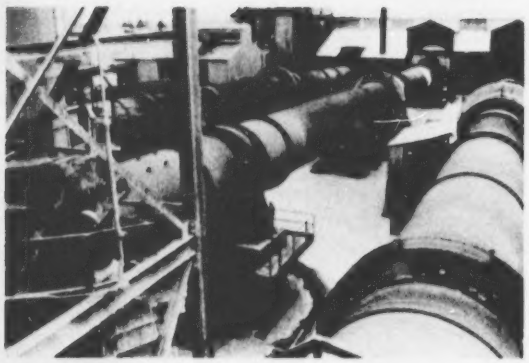
A high quality science program is never exclusively text-oriented. Laboratory experiences, field study, and hands-on learning are just as important as textbook learning. Some teachers of science rarely use a textbook.

When a basic textbook or science program is used, the decision about which text or program to adopt will be critically important. At the elementary level, teachers and other school-level planners may wish to examine available textbooks and kits by visiting one of the 30 Instructional Materials Display Centers (IMDCs) around the state (see Resources Section). They may also wish to use some of the available materials on a trial basis in the classroom. Whichever textbook is selected, it should be consistent with school-level and district-level goals for science education.

Textbook selection is more complex at the secondary level. Publishers will often make available sample copies of textbooks and teacher manuals. Displays at professional meetings can be a rich source of ideas and new materials.

Even when a basic textbook has been selected, teachers in a high quality program continue to keep abreast of new developments, because textbooks in science are often outdated before they are

A high quality science program is never exclusively text-oriented.



Businesses, industrial plants, manufacturers, farmers, food processing plants, and utility companies are increasingly interested in helping students learn about their products and services.

printed. Effective teachers of science regularly review new publications, such as booklets, pamphlets, popular magazines, and professional journals.

Inexpensive Supplementary Materials

Science textbooks and laboratory materials are major purchases. Teachers have become increasingly inventive, therefore, in creating their own science materials out of inexpensive or free items. Effective teachers of science regularly seek out inexpensive resources and make use of what is immediately available, even if this means modifying their plans to accommodate a new resource "find."

Museums and Science Institutions

Most California students live near a variety of museums and science-oriented institutions that provide great opportunities for supplementary science activities and explorations. Usually, these institutions offer courses for students throughout the year, and some operate summer camps specializing in science.

Also useful to school programs are the visiting science teachers that museums and other science institutions make available, usually at no cost to the school. These may include traveling animal displays or mobile tents that can be set up in a school auditorium to duplicate the celestial display of a planetarium.

Local conservation organizations are another valuable resource for science education. Often these organizations publish youth-oriented newsletters or magazines. Many maintain wilderness retreats, biological study areas, bird sanctuaries, or recycling centers. Organization staff members are often eager to assist teachers in developing continuing programs and science education units.

Businesses, industrial plants, manufacturers, farmers, food processing plants, and utility companies are increasingly interested in helping students learn about their products and services, and plant tours have become sophisticated learning experiences. Many businesses now make a variety of educational materials available to schools as well. Responsible teachers examine these materials carefully for bias and misinformation.

Parental Involvement in the Science Program

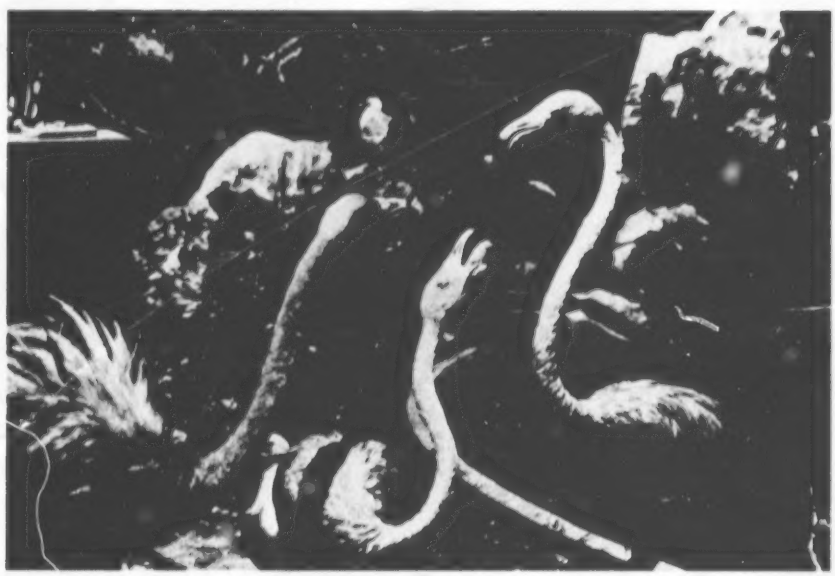
Parental involvement is another important means of supplementing classroom instruction in science. Teachers in high quality science programs furnish students and their parents with lists of recommended outings to health centers, research laboratories, and ecology centers. They encourage parents to take their children to zoos, museums, and planetariums. Many of these educational opportunities make interesting family outings or playgroup activities for preschool children as well. Even parents who do not have any specialized knowledge of science can encourage their children to read about tidepools on a teacher-prepared assignment sheet before a trip to the beach; then, during the trip, the entire family can explore marine life. Similarly, a trip to the mountains can be an opportunity to study geology.

Teachers in high quality programs regularly reinforce the educational links between home and school by providing parents with information about science education opportunities that they and their children can share.

Questions for Determining Whether or Not You Are Giving Adequate Attention to the Use of Resources in the School and Community

1. Do teachers regularly develop or acquire free or inexpensive materials to supplement existing classroom kits and laboratory materials?
2. Do students visit local science museums and other science-related institutions, and do staff members of these institutions make presentations to students at school?
3. Do students take field trips to natural outdoor settings, assisted by local conservation and wildlife organizations?
4. Do students have opportunities to learn about scientific and technological advances being made or employed by local businesses and industries?
5. Do teachers of science help parents to initiate and lead activities outside of school in which the entire family can be involved; i.e., by providing parents with science work sheets and guides?
6. Are commercially sponsored materials carefully screened to make sure that information about science and technology will be presented in an accurate, nonbiased manner?

Teachers in high quality science programs encourage parents to take their children to zoos, museums, and planetariums.



Checklist

All of the questions asked throughout this publication have been compiled into the checklist on the following pages. The checklist was designed to be used in the process of conducting an actual on-site assessment of a school's science program. It is important, however, that readers familiarize themselves first with the contents of the preceding chapters. The information in those chapters provides suggestions and specific recommendations to make the checklist meaningful and ultimately useful.

School-Level Planning for a High Quality Science Education Program

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Developing a school-level plan for a high quality science education program and making it readily available in written form?	___	___	___	___
2 Making the plan consistent with local school district policies?	___	___	___	___
3 Making certain that each teacher in the school is aware of his or her role in implementing the plan and giving each one an opportunity to participate in developing or modifying the plan if he or she wishes?	___	___	___	___
4 Ensuring that the *Science Framework for California Public Schools* and the county superintendents' *Course of Study* are used by those designing the school-level plan?	___	___	___	___
5 Developing a plan that contains realistic, attainable goals and objectives based on assessed needs?	___	___	___	___
6 Adopting goals and objectives that reflect new scientific and technological developments with which students will need to be acquainted?	___	___	___	___
7 Holding regular meetings in which administrators, teachers, parents, students, and others involved in implementing the school-level plan discuss modifications in the plan, ways of implementing it, and ways of evaluating its success?	___	___	___	___
8 Making science textbooks and related materials available to all students?	___	___	___	___
9 Having enough textbooks available so that students can take them home?	___	___	___	___
10 Developing a physical setting of classrooms and a school environment, in general, that supports science education?	___	___	___	___

School-Level Planning for a High Quality Science Education Program

How effective is your school in providing for each of the following:		Ineffective	Somewhat effective	Effective	Very effective
11	Involving all the students in some aspect of science education?	___	___	___	___
12	Making science classes available to students throughout the school year?	___	___	___	___
13	Making information about the science education program available to parents on a regular basis?	___	___	___	___
14	Developing a plan that clearly provides for the allocation of resources (staff, rooms, materials, financial support) for the science education program?	___	___	___	___
15	Identifying at least one person in the school clearly identified as having a leadership role for science education?	___	___	___	___
16	Making the science education plan an integral part of other school plans, such as the ones for school improvement and compensatory education?	___	___	___	___

Consistency and Articulation in Your Science Education Program

How effective is your school in providing for each of the following:		Ineffective	Somewhat effective	Effective	Very effective
1	Ensuring that the content of the science education program is clearly documented in a curriculum guide?	___	___	___	___
2	Ensuring that all students will receive instruction in the basic content areas of science and that the instruction will be appropriate to their respective grade levels?	___	___	___	___
3	Ensuring that the curriculum guide is being implemented consistently and uniformly schoolwide; i.e., appropriate textbooks and materials are being used at the grade levels for which they were designated, and students are regularly assessed to determine whether or not they are acquiring the values, skills, and knowledge specified in the curriculum guide?	___	___	___	___
4	Holding regular meetings of staff members and other school-level planners to discuss the consistency and sequence of the curriculum and to make modifications that will continue to support the basic sequential design?	___	___	___	___

Consistency and Articulation in Your Science Education Program

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
5 Developing procedures for school staff and program planners to follow in order to maintain consistency and articulation among science classes?				
6 Ensuring that students study science in every grade from kindergarten through grade twelve, following an agreed-upon sequential plan?				
7 Providing for all high school students to enroll in at least one science course each year?				
8 Providing help for students who enter the program midyear and who have not covered portions of the curriculum?				

Standards and Expectations

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Adopting schoolwide standards for homework, academic performance, classroom behavior, workmanship, and so forth, which are included in the written plan?				
2 Making students and parents aware of the adopted standards and the consequences for not meeting them?				
3 Applying the standards uniformly?				
4 Encouraging teachers, students, and parents to regard academic achievement as a highly positive attribute?				
5 Encouraging students to complete homework on time?				
6 Making certain that teachers and students are on time and prepared to begin work when class begins?				
7 Making students and parents aware of the amount and quality of academic work necessary to receive a specified grade?				
8 Making students and parents aware of the standards of thoroughness, neatness, care, and precision expected of students' work?				

The Amount and Quality of Time Spent on Science Education

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Allocating a specific amount of time for science education for each student during each school week and making that a provision of the school-level plan?	____	____	____	____
2 Encouraging students to become positively and actively involved in science classes?	____	____	____	____
3 Varying science activities sufficiently to allow different kinds of student participation and engagement; e.g., combination of lectures, laboratory activities, discussions, small group activities, and field studies?	____	____	____	____
4 Encouraging teachers to make homework assignments that review and reinforce concepts learned in class and letting students know they are expected to complete the assignments?	____	____	____	____
5 Requesting that students complete reading assignments before class time?	____	____	____	____
6 Contacting parents when students fail to complete homework assignments on time?	____	____	____	____
7 Having well-known and uniformly applied consequences for not completing the homework assignments on time?	____	____	____	____
8 Training parents to supervise and assist their children with homework?	____	____	____	____

Coordinating Science with Other Curriculum Areas

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Encouraging teachers to use science content regularly in the teaching of reading, writing, mathematics, social studies, art, and other areas?	____	____	____	____
2 Displaying written essays, reports, poetry, and art projects that incorporate science-related content?	____	____	____	____
3 Having students keep journals describing what they have learned in science classes or noting the progress of experiments?	____	____	____	____

Coordinating Science with Other Curriculum Areas

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
4 Holding regular meetings of the school staff, parents, and science specialists to discuss ways of coordinating science with other areas of the curriculum?				
5 Having the various departments at the secondary level meet to discuss ways of coordinating science education with other disciplines; i.e., using science as a tool for teaching writing or art?				
6 Encouraging and giving opportunities to teachers to participate on interdisciplinary teams that allow for a variety of approaches to teaching science and other subjects?				

Provisions for Financial Support

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Having the school administration make a commitment to continuous financial support of science education by providing for it in the school budget?				
2 Adopting a budget that provides for a balance of program components, such as materials and staff development?				
3 Making funds for consumable or perishable materials readily accessible to teachers?				
4 Investigating a variety of funding sources for science education, including school improvement, compensatory education, and other state and federal programs?				

The Appropriateness of Course Content and Curriculum

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Having the program planners examine a wide variety of curriculum guides, textbooks, and other materials as part of the process of curriculum planning?				
2 Ensuring that the information in science textbooks and materials is valid, accurate, and up-to-date?				

The Appropriateness of Course Content and Curriculum

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
3 Making certain that the course content being learned by students is consistent with the basic goals of the *Science Framework for California Public Schools:* attainment of positive attitudes toward science; attainment of manipulative and communicative skills in science; and attainment of scientific knowledge?				
4 Keeping teachers informed about new materials and significant new developments in science?				
5 Establishing at the elementary level a balance of instruction in life science, earth science, and physical science?				
6 Offering at the secondary level a wide variety of courses each year, including advanced courses, general courses, and minicourses in specialized areas of science?				
7 Ensuring that the sequence of the curriculum reflects students' general orientation to the world around them?				

Teaching Methods

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Encouraging teachers of science to use a variety of teaching methods, such as demonstrations, group experiments, modeling, discussion, multimedia instruction, individual investigation or research, student tutoring, and questioning?				
2 Encouraging teachers to modify their teaching methods to take into account the needs, strengths, and interests of individual students or groups?				
3 Permitting high school students to choose among classes and teachers that offer a variety of instructional methods and teaching styles?				
4 Encouraging teachers to modify their teaching methods when evaluation data or direct observation indicate that these methods are not successful?				
5 Assessing student learning regularly through quizzes, tests, examinations, and reports?				
6 Checking students continually to determine whether they are understanding what is being taught?				

Creating an Effective Balance Between the Use of Laboratory Materials and Written Materials

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Encouraging science teachers to use laboratory and other hands-on materials in conjunction with written materials, such as textbooks, activity cards, work sheets, curriculum guides, and students' written reports or stories?	___	___	___	___
2 Refurbishing or replenishing science materials on a regular basis?	___	___	___	___
3 Encouraging students who have successfully completed laboratory experiments to look for additional insights by referring them to books, periodicals, and other written materials?	___	___	___	___
4 Making materials for science education readily available to all teachers who want and need them?	___	___	___	___
5 Using written materials as both an introduction to laboratory experiments and as a follow up to the experiments?	___	___	___	___
6 Having teachers give attention to inventory, ordering, storage, safety, and disposal of materials?	___	___	___	___

Sustaining Student Involvement and Motivation in Science

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Allowing time in classes for open discussion of science and related topics so that students feel free to ask questions?	___	___	___	___
2 Encouraging teachers to modify lessons, when necessary or appropriate, to take students' needs and interests into account?	___	___	___	___
3 Giving students opportunities to initiate scientific investigations and explorations in areas of special interest?	___	___	___	___
4 Translating current events into interesting science activities?	___	___	___	___
5 Encouraging students to explore science-related issues and to test hypotheses?	___	___	___	___

Sustaining Student Involvement and Motivation in Science

How effective is your school in providing for each of the following:		Ineffective	Somewhat effective	Effective	Very effective
6	Securing an adequate number of science materials for students who have limited proficiency in English and making certain that teachers use these materials sensitively and adequately?	___	___	___	___
7	Ensuring that students who have limited proficiency in English are as involved in science classes as students who are fluent in English and that they are learning the same concepts as those which students who are fluent in English are learning?	___	___	___	___
8	Giving handicapped students adequate opportunities to participate in science classes and providing handicapped students with adequate opportunities and special learning materials to become actively involved in laboratory activities? Ensuring that handicapped students are learning the same concepts that nonhandicapped students are learning?	___	___	___	___
9	Giving gifted and talented students adequate opportunities to pursue science projects and interests in science independently, in groups, and in tutorials with teachers, older students, and volunteers?	___	___	___	___
10	Providing science-oriented extracurricular activities and making students aware, on a regular basis, of such activities?	___	___	___	___
11	Involving the staff of special programs (e.g., special education teachers, bilingual education teachers) in the planning of the science education program?	___	___	___	___

Careers in Science and Science-Related Fields

How effective is your school in providing for each of the following:		Ineffective	Somewhat effective	Effective	Very effective
1	Giving students at all grade levels and ability levels opportunities to meet and talk with people in science-related fields, both in school and in their job settings; to learn what they do; and to explore long-range career goals?	___	___	___	___
2	Making students aware of the need to maintain career options by taking as many mathematics and science courses as possible?	___	___	___	___

Careers in Science and Science-Related Fields

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
3 Providing students regularly with information about science-oriented job opportunities for teenagers and entry-level positions in science-related occupations that may not require advanced science courses?	___	___	___	___
4 Advising students of the requirements and recommendations for admission to specific college programs involving science?	___	___	___	___
5 Offering courses and other opportunities for noncollege-bound students to pursue science-related careers?	___	___	___	___
6 Ensuring that school counselors are aware of and informed about science-related career options?	___	___	___	___
7 Making information about science-oriented careers available and offering career counseling to students who request it?	___	___	___	___
8 Letting students know where they can obtain counseling relevant to science-oriented careers?	___	___	___	___
9 Encouraging graduates of the school to visit the school regularly to offer students information and counseling regarding science-oriented careers?	___	___	___	___
10 Having the school's science teachers assist the guidance department in acquiring and maintaining current and reliable information about science-oriented careers for counselees?	___	___	___	___

Staffing and Staff Development

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Assigning those teachers who are most interested and skilled in science responsibility for teaching science?	___	___	___	___
2 Making supplemental staffing available through the use of aides, resource people, specialists, volunteers, interns, and visiting teachers from community agencies, science centers and museums, and colleges and universities?	___	___	___	___

Staffing and Staff Development

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
3 Involving parents and others in the community who are knowledgeable or experienced in particular aspects of science in planning and implementing the program?	___	___	___	___
4 Having school staff members assist in designing staff development programs based on clearly identified needs?	___	___	___	___
5 Making the staff development program consistent with the school's planned program for science education?	___	___	___	___
6 Continuing the staff development program over an extended period of time and allowing for training, skill development, classroom observation, additional follow-up and coaching?	___	___	___	___
7 Scheduling staff development sessions so that teachers can participate with a minimum of fatigue, disrupted schedules, and loss of time in the classroom?	___	___	___	___
8 Giving teachers opportunities to practice new skills that they are learning or to experiment with new materials before trying them out in the classroom?	___	___	___	___
9 Offering a staff development program that helps teachers gain specific skills and techniques and secure materials that can be immediately useful to them?	___	___	___	___
10 Offering a staff development program that provides training for science teachers in how to teach the basic skills of reading, writing, and computation in secondary science classes?	___	___	___	___
11 Establishing a professional library with science materials so that teachers are continually able to come in contact with new ideas and developments in the field? Encouraging teachers to use this library regularly?	___	___	___	___
12 Developing a staff development program that provides for such important aspects of a high quality science program as the renewal and updating of information about scientific developments; research relevant to science education; and ways of coordinating science education with instruction in other disciplines?	___	___	___	___
13 Encouraging teachers to participate in professional organizations, meetings, and conferences in order to upgrade their skills in science education?	___	___	___	___
14 Supporting teacher in-service training programs?	___	___	___	___

The Use of Resources in the School and Community

How effective is your school in providing for each of the following:	Ineffective	Somewhat effective	Effective	Very effective
1 Encouraging teachers to develop or to acquire free or inexpensive materials to supplement existing classroom kits and laboratory materials?	___	___	___	___
2 Scheduling visits to local science museums and other science-related institutions and inviting staff members of these institutions to make presentations to students at school?	___	___	___	___
3 Scheduling field trips to natural outdoor settings with the help of local conservation and wildlife organizations?	___	___	___	___
4 Giving students opportunities to learn about scientific and technological advances being made or employed by local businesses and industries?	___	___	___	___
5 Helping parents initiate and lead activities outside of school in which the entire family can be involved; e.g., by providing parents with science work sheets and guides?	___	___	___	___
6 Screening commercially sponsored materials to make sure that information about science and technology is presented in an accurate, nonbiased manner?	___	___	___	___

4

Resources

State School Resource Centers[1]

Deciding that preservice education does not fully prepare teachers and other school staff to meet the diverse and changing needs of students, the California Legislature in 1977 enacted Assembly Bill 551, which established the State School Resource Center Program. The centers established under this program facilitate the development of in-service education programs that are designed by the local school staffs to meet their particular needs. Upon request, personnel at these centers help local school staffs to determine their in-service education needs and then assist them to plan, implement, and evaluate their local staff development programs.

Eligible participants for local staff development activities include all persons who work directly on a regular basis with students, including teachers, administrators, pupil services employees, paraprofessionals, and volunteers. In 1980-81 state school resource centers were in operation in the following locations in California:

Alameda County Schools Office
685 A Street
Hayward, CA 94541
(415) 881-6234

Claremont Unified School District
2080 North Mountain
Claremont, CA 91711
(714) 624-9041

Imperial County Schools Office
Education Center
155 S. 11th Street
El Centro, CA 92243

Kings County Schools Office
Kings County Government Center
Hanford, CA 93230
(209) 584-1441

Los Angeles County Schools Office
9300 East Imperial Highway
Downey, CA 90242
(213) 922-6365

Merced County Schools Office
632 West 13th Street
Merced, CA 95340
(209) 723-2031

Riverside County Schools Office
P.O. Box 868
Riverside, CA 92502
(714) 787-2292

San Joaquin County Schools Office
222 East Weber Avenue, Room 407
Stockton, CA 95220
(209) 944-2684

Solano County Schools Office
655 Washington Street
Fairfield, CA 94553
(707) 429-6646

Sonoma County Schools Office
2555 Mendocino Avenue, Room 11E
Santa Rosa, CA 95401
(707) 527-2171

Tehama County Schools Office
P.O. Box 810
Red Bluff, CA 96080
(916) 527-5811

Vallejo Unified School District
211 Valle Vista
Vallejo, CA 94590
(707) 643-2531

Ventura County Schools Office
535 East Main Street
Ventura, CA 93009
(805) 654-2164

Instructional Materials Display Centers (IMDC)

IMDC #1
Humboldt County Schools
901 Myrtle Ave.
Eureka, CA 95501

IMDC #2
Shasta County Schools
1644 Magnolia Ave.
Redding, CA 96001

IMDC #3
LARC Curriculum
Materials Center
California State University
Chico, CA 95929

[1]For more information about school resource centers, contact the Office of Staff Development, State Department of Education, 721 Capitol Mall, Sacramento, CA 95814, (916) 322-5537.

Instructional Materials Display Centers (IMDC)

IMDC #4
Placer County Schools
360 Nevada Street
Auburn, CA 95603

IMDC #5
Sacramento County Schools
9738 Lincoln Village Dr.
Sacramento, CA 95827

IMDC #6
Sonoma County Schools
2555 Mendocino Ave., Rm. 111-E
Santa Rosa, CA 95401

IMDC #7
Alameda County Schools
685 A St.
Hayward, CA 94541

IMDC #8
Stanislaus County Schools
801 County Center III Ct.
Modesto, CA 95355

IMDC #10
Fresno County Schools
2314 Mariposa St.
Fresno, CA 93721

IMDC #11
Monterey Peninsula
Unified School District
540 Canyon del Rey
Monterey, CA 93940

IMDC #12
Kern County Schools
5801 Sundale Ave.
Bakersfield, CA 93309

IMDC #13
Library, Room 1414
University of California
Santa Barbara, CA 93106

IMDC #14
Glendale Unified School District
223 N. Jackson St.
Glendale, CA 91206

IMDC #15
California State College
5500 State College Pkwy.
San Bernardino, CA 92407

IMDC #16
Los Angeles Unified School District
1320 W. 3rd St.
Los Angeles, CA 90017

IMDC #17
Los Angeles County Schools
9300 East Imperial Highway
Downey, CA 90242

IMDC #18
Riverside County Schools
3939 - 13th St.
Riverside, CA 92502

IMDC #19
Orange County Schools
1300 S. Grand Ave., Bldg. B
Santa Ana, CA 92711

IMDC #20
Imperial County Schools
625 State St.
El Centro, CA 92243

IMDC #21
San Diego County Schools
6401 Linda Vista Rd.
San Diego, CA 92111

IMDC #22
California State Department of Education
560 J St., Suite 290
Sacramento, CA 95814

IMDC #24
Contra Costa County Schools
2371 Stanwell Dr.
Concord, CA 94520

IMDC #25
Oakland Unified School District
314 E. 10th St.
Oakland, CA 94606

IMDC #26
San Francisco Unified School District
2550 - 25th Ave.
San Francisco, CA 94006

IMDC #27
San Mateo County Schools
333 Main St.
Redwood City, CA 94063

IMDC #28
Merced County Schools
632 W. 13th St.
Merced, CA 95340

IMDC #29
Inyo County Schools
135 Jackson St.
Independence, CA 93526

IMDC #30
Tulare County Schools
602 S. Bridge St., Suite B
Visalia, CA 93277

IMDC #31
Learning Resources and Curriculum Department
California Polytechnic State University
San Luis Obispo, CA 93401

IMDC #32
Desert Sands Unified School District
83-651 Avenue 47
Indio, CA 92201

Professional Development and Program Improvement Centers

The Professional Development and Program Improvement Centers provide a comprehensive program of in-service training to strengthen the instructional and supervisory skills of teachers, administrators, and aides, kindergarten through grade twelve. This in-service training is primarily in the areas of reading and mathematics, and it is focused on skills in diagnosing learning disabilities and developing corrective methods of instruction. The PDPICs also include a program for the principal and other school administrative personnel designed to improve their supervision of the teaching/learning process. Additionally, the PDPICs serve as incentives to local educational associations to integrate all other local, federal, and state money resources related to teacher and administrator in-service training. The state money allocated is matched by an actual dollar commitment from LEAs and county offices. This requirement facilitates integration of existing staff development programs and further supports the improvement of the educational achievement of students enrolled in both categorical aid and regular programs.

Further information about these centers, which are listed below, may be obtained by contacting the Office of Staff Development, California State Department of Education, 721 Capitol Mall, Sacramento, CA 95814, telephone (916) 322-5537:

Butte County Schools Office
P.O. Box 397
Durham, CA 95938
(916) 895-1501

Humboldt County Schools Office
901 Myrtle Avenue
Eureka, CA 95501
(707) 445-5411

Lake County Schools Office
1152 South Main
Lakeport, CA 95453
(707) 263-3080

Long Beach Unified School District
2335 Webster Avenue
Long Beach, CA 90813
(213) 426-3986

Napa County Schools Office
4032 Maher Street
Napa, CA 94558
(707) 224-3151

Orange County Schools Office
1300 South Grand Avenue
Santa Ana, CA 92711
(714) 552-5011

Placentia Unified School District
1301 East Orangethorpe Avenue
Placentia, CA 92670
(714) 524-4376

Placer County Schools Office
1230 High Street
Auburn, CA 95603
(916) 823-6222

Rowland Unified School District
1830 Nogales Street
Rowland Heights, CA 91748
(213) 965-2541

San Diego Unified School District
4100 Normal Street
San Diego, CA 92103
(714) 293-8264

San Juan Unified School District
3738 Walnut Avenue
Carmichael, CA 95608
(916) 944-3614

San Luis Obispo County Schools Office
2156 Sierra Way
San Luis Obispo, CA 93401
(805) 543-7732

Tehama County Schools Office
1135 Lincoln Street
P.O. Box 810
Red Bluff, CA 96080
(916) 527-5811

Upland School District
904 West Ninth Street
Upland, CA 91786
(714) 985-1864

Vallejo Unified School District
211 Valle Vista
Vallejo, CA 94590
(707) 643-2531

Ventura County Schools Office
535 East Main Street
Ventura, CA 93009
(805) 654-2749

Visalia Unified School District
315 East Acequia Street
Visalia, CA 93277
(209) 625-6774

Science Associations

California Science Teachers Association
Lawrence Hall of Science[1]
University of California
Berkeley, CA 94720
(415) 642-4155

National Science Teachers Association
1742 Connecticut Ave., NW
Washington, DC 20009

State Department of Education

Science Education Consultant
Instructional Services Unit
State Department of Education
721 Capitol Mall
Sacramento, CA 95814
(916) 322-4015

County Offices of Education

For additional resources, contact the office of your county superintendent of schools.

Science and Disabled Students—Resources

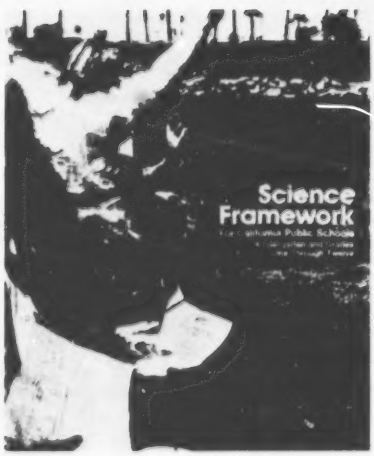
Center for Multisensory Learning
Lawrence Hall of Science
University of California, Berkeley
Berkeley, CA 94720
(415) 642-3679

[1]Two projects are available through the Lawrence Hall of Science that provide materials and training to teachers in the area of special education: Science Activities for the Visually Impaired (SAVI) and Science Enrichment for Learners with Physical Handicaps (SELPH).

Other Publications Available from the Department of Education

Science Education for the 1980s is one of approximately 500 publications that are available from the California State Department of Education. Some of the more recent publications or those most widely used are the following:

Arts for the Gifted and Talented, Grades One Through Six (1981)	$2.75
Bilingual Program, Policy, and Assessment Issues (1980)	3.25
California Private School Directory	5.00
California Public School Directory	11.00
California Public Schools Selected Statistics	1.50
California School Accounting Manual (1981)	2.50
California Schools Beyond Serrano (1979)	.85
California's Demonstration Programs in Reading and Mathematics (1980)	2.00
Discussion Guide for the California School Improvement Program (1978)	1.50*†
District Master Plan for School Improvement (1979)	1.50*
Education of Gifted and Talented Pupils (1979)	2.50
Establishing School Site Councils: The California School Improvement Program (1977)	1.50*†
Foreign Language Framework for California Public Schools (1980)	2.50
Guide to California Private Postsecondary Career Education (1980)	5.00
Guide to School and Community Action (1981)	1.75
Guidelines and Procedures for Meeting the Specialized Health Care Needs of Students (1980)	2.50
Guidelines for School-Based Alcohol and Drug Abuse Programs (1981)	1.00
Handbook for Planning an Effective Mathematics Program (1982)‡	
Handbook for Planning an Effective Reading Program (1979)	1.50*
Handbook for Planning an Effective Writing Program (1982)‡	
History—Social Science Framework for California Public Schools (1981)	2.25
Improving the Human Environment of Schools (1979)	2.50
Improving Writing in California Schools (1982)‡	
Instructional Materials Approved for Legal Compliance (1981)	3.50
Interim Guidelines for Evaluation of Instructional Materials with Respect to Social Content (1981)	1.50
Manual of First Aid Practices for School Bus Drivers (1980)	1.25
Mathematics Framework for California Public Schools, with 1980 Addendum (1982)	2.00
Monograph on Staff Development (1980)	1.50
New Era in Special Education: California's Master Plan in Action (1980)	2.00
Pedestrian Rules of the Road in California—Primary Edition (1980)	1.50
Physical Performance Test for California, Revised Edition (1981)	1.50
Planning for Multicultural Education as a Part of School Improvement (1979)	1.25*
Planning Handbook (1978)	1.50*
Proficiency Assessment in California: A Status Report (1980)	2.00
Proficiency Skill Development Kit (1980)	7.50
Putting It Together with Parents (1979)	.85†
Reading Framework for California Public Schools (1980)	1.75



Wherever possible, the curriculum in science education is consistent with the recommendations of the *Science Framework for California Public Schools.*

*Developed for implementation of the School Improvement Program.
†Also available in Spanish, at the price indicated.
‡In process. Please inquire before ordering.

Relationship Between Nutrition and Student Achievement, Behavior, and Health (1980)	4.00
Science Framework for California Public Schools (1978)	1.65
School Improvement: Making California Education Better (brochure) (1981)	NC*
Student Achievement in California Schools	1.75
Students' Rights and Responsibilities Handbook (1980)	1.50†
Teaching About Sexually Transmitted Diseases (1980)	1.65
Toward More Human Schools (1981)	1.75
Visual and Performing Arts Framework (1982)‡	

Orders should be directed to:

California State Department of Education
P.O. Box 271
Sacramento, CA 95802

Remittance or purchase order must accompany order. Purchase orders without checks are accepted only from government agencies in California. Sales tax should be added to all orders from California purchasers.

A complete list of publications available from the Department may be obtained by writing to the address listed above.

80-241 (03-0646) 82908 2-82 22M